Application Brief

Optimizing Indoor Air Conditioner Units With 5V MSPM0H MCUs

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Today, Air Conditioner Units are devices that offer a wide range of features to facilitate cooling in various places and locations. These features include temperature detection and control, air speed, and IoT capabilities. All of these features require a microcontroller (MCU) to collect information from sensors inside the system, communicate with other MCUs in the system, and control different operating modes, LEDs, and other essential peripherals. TI's MSPM0H MCUs are an excellent choice for integration in these applications, thanks to their 5V-capable power management system, low power consumption, high-performance features such as advanced timers, timer frequency multiplier, metering capabilities, a functional safety library, pin-to-pin compatibility with other industry-standard MCUs, and competitive pricing.

What are the common components in a Indoor Air Conditioner Unit?

Indoor Air Conditioner Unit-related applications are composed of several modules that are responsible for specific tasks. The most common modules to find are the following:

1. Display and/or Audio Module
2. Main System Control
3. Fan V/F (Variable Frequency Drive) or Motor Drive Module

In many designs, both the Main System Control and Motor Drive module are combined into a single solution. In contrast, the display and/or Audio module is commonly handled by a dedicated interface MCU. Moreover, some applications require isolating specific parts of the system, such as the display module, to prevent users from coming into contact with the high-power areas of the Indoor Air Conditioner Unit. For these designs, some of the main components include:

- **Brushless DC motor**: Converts electrical energy into mechanical energy (torque).
- **Motor control**: PWM logic control signals based on real-time motor position, temperature, and current feedback, which are translated to driver signals to switch MOSFETs, energize motor windings, and deliver current to commutate the motor. A motor driver and MCU solution is commonly found in most applications.

Gallium nitride (GaN) intelligent power modules are ideal for these applications since they can handle the high voltage levels needed to control Air Conditioner fans, reduce the amount of motor control components and layout footprint, and have high power efficiency that allows them not to require a heatsink for applications that require 250W or less. You can use the DRV7308EVM to test out its functions and features, and the TIDA-010273 reference design.

- **Input user interface**: Selects the air conditioner operation mode such as cooling and heating, fan speed and air flow direction, and system ON/OFF.
- **Output user interface**: Provides visual feedback using LEDs, LCDs, or audible feedback using speakers.
- **MCU**: Leverages integrated digital and analog modules to commutate the motor based on the input user interface, communicate with other devices in the system, and provide an output user interface for system status.

TI offers a wide selection of devices that can be used in various components for Indoor Air Conditioner Unit applications, a few of which are highlighted below.

Motor	MCU	Motor driver (GaN IPM)	Motor Voltage (AC & DC)	Sensor trap/FOC & Sensorless FOC
Brushless-DC	MSPM0Hxxxx Arm Cortex M0+ 32MHz MCUs	GaN IPM (DRV73xx series)	120V to 265V & 150V to 450V	Hall Sensor (DRV5xxx series)

Based on these main components, we can divide this application into two types of arrangements:

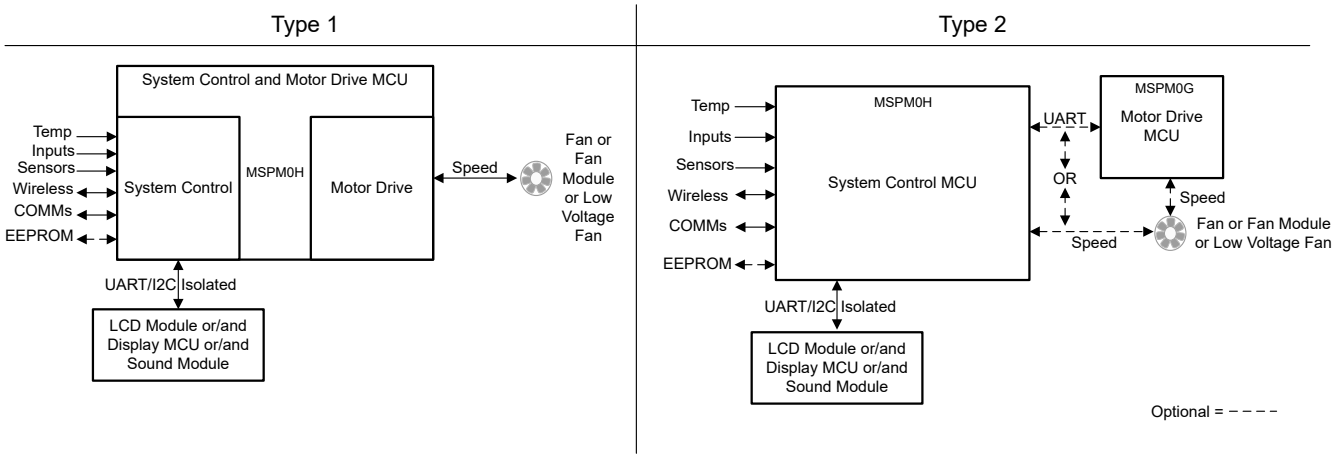


Figure 1. Indoor Air Conditoner Units System Module Arrangement types

Type 1 - Main System Control and Motor Control MCU solution

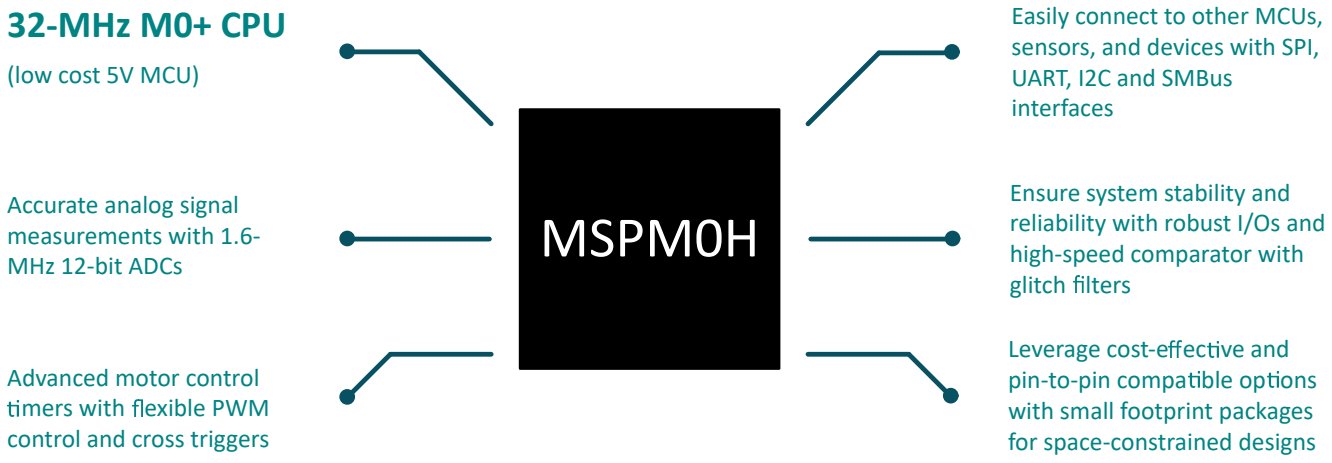
In this arrangement, the MCU is responsible for overseeing system signals, including temperature, inputs from other modules, GPIOs, capacitive sensors, and other types of sensors; communicating with the Outdoor Air Conditioner Unit, wireless transceivers, display, external EERPOMs, or audio MCUs/modules; and controlling motors through Motor Drivers or GaN IPMs for both low- and regular-fan motors. The isolated area will mainly consist of the input and output/display modules.

Type 2 - Main System Control MCU plus Fan Module/MCU Drive solution

In this arrangement, the Main System Control MCU is responsible for the tasks mentioned in Type 1. It either directly controls the speed of a motor through simple motor control (alongside half-bridges and MOSFETs) via a motor driver/module or through a Motor Control MCU. The Motor Control MCU sometimes doesn't require 5V support, making the MSPM0G MCU family the perfect fit for this module, thanks to its multiple analog peripherals used for monitoring the motor state, its advanced timers for controlling the motors, and its high-speed processing power (80MHz). Usually, both devices communicate through UART to update each other on the latest status of the device (from the Main System Control MCU) and motor status (from the Motor Control MCU).

Why is MSPM0H considered for Indoor Air Conditioner Unit applications?

Texas Instruments' scalable MSPM0H MCU features an Arm® 32-bit Cortex-M0+ core with a maximum CPU speed of 32 MHz. The device is capable of supporting up to 5.5V operations. This pin-to-pin compatible MCU offers up to 64KB of flash memory with scalable analog integration and motor control modules. With extensive digital, analog, and interface integration, MSPM0H can provide a high-performance and robust option for motor control designs and analog signal monitoring. Moreover, the MSPM0H family offers a Motor Driver library to control various types of motor drivers, as well as code examples for monitoring the device's voltage supply, which can be used for simple metering monitoring.



Key features the MSPM0H MCUs offer for these applications:

- General-purpose and Advanced timers with complementary PWM outputs
- Advanced timer multiplier capable of doubling the base device's frequency for the timer source (Up to 64MHz)
- 12-bit 1.6-Msps analog-to-digital converter (ADC)
- Communication interfaces (UART, I2C, SPI)
- General-purpose inputs and outputs(GPIOs)
- Up to 64KB of flash memory

Software functions performed on the MCU:

- Control motor speed by generating pulse-width modulation signals (PWMs) based on trigger position, thanks to hall sensor feedback/support a sensorless FOC solution (thanks to current detection)
- Continuously measure and handle any system feedback signals, such as voltage and current (sensing/processing)
- Monitor the temperature of the system's different parts or perform basic metering functionality through its internal ADC
- Communicate periodically with the Outdoor Air Conditioner unit, WiFi transmitters, display and audio modules, external EEPROM (if needed), and leak detection modules
- Control GPIO outputs and inputs, as well as LED Drivers
- Safety library that reduces development effort for EC60730 Class B certification

You can order the LP-MSPM0H3216 to test out the MSPM0H functions and features.

What can MSPM0H do in Indoor Air Conditioner Unit applications?

Most modern Indoor Air Conditioner Units will only use a single MCU to handle most of the critical control parts of the Air Conditioner's functionality. From controlling the Air fans to monitoring the system's temperature, the Main System Control requires that the MCU is not only capable of sensing and controlling, but also communicating with adjacent modules.

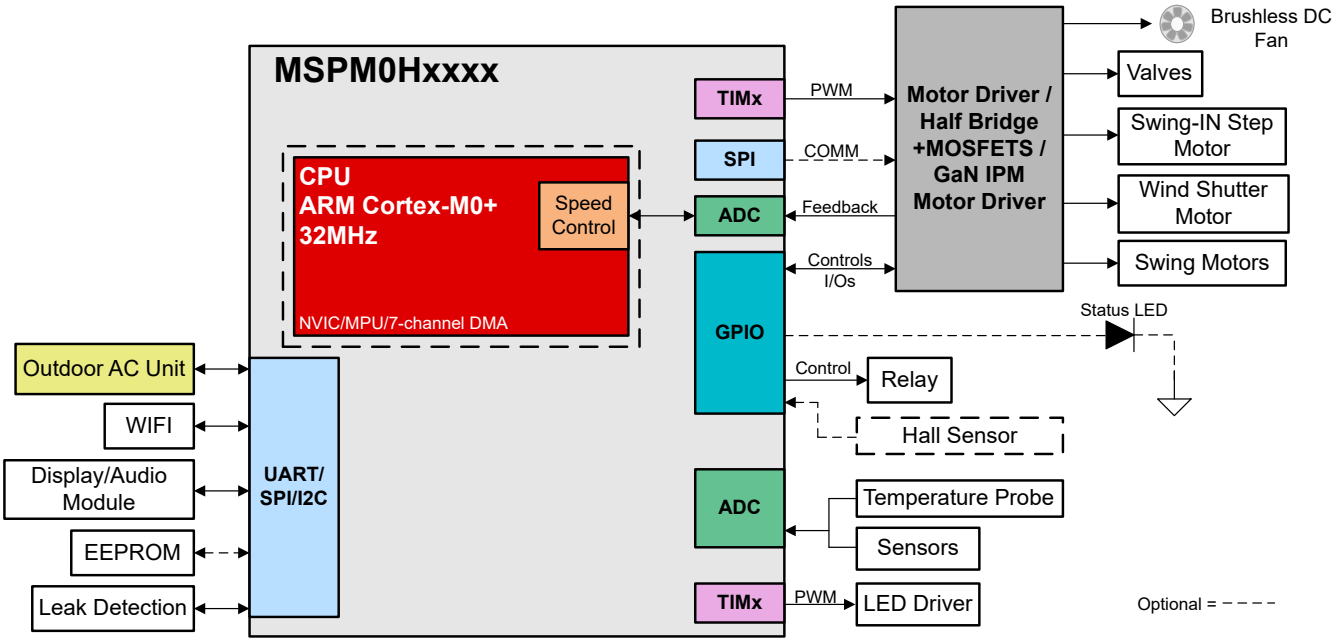


Figure 2. MSPM0Hxxxx Block Diagram for Main System Control and Motor Drive Module in Indoor Air Conditioner Units

For Main System Control and Motor Drive Modules

In this type of system, the MCU must be able to handle the minimum required voltage for these applications, which is typically around 5V. The MCU executes a motor control algorithm to regulate the motor speed and (sometimes) direction, while monitoring temperature and other sensors that affect the motor's behavior. Some applications may use Sensor trap/FOC (utilizing a Hall Sensor) or Sensorless FOC (measuring the motor current). The MSPM0H can easily manage either case thanks to its internal analog parts. Typically, the MCU also acts as the main processor in the system, controlling other components such as status LEDs, electrical components like relays, and communicating with other devices, including Wi-Fi devices/transmitters, display and audio MCUs, external EEPROM, leak detection modules, and the Outdoor Air Conditioner Unit. Texas Instruments' 32-MHz MSPM0H MCUs are a cheap, reliable, and relatively low-power-consuming option for these modules.

For Main System Control only

In this type of system, the MCU will be responsible for the previously mentioned tasks, except for handling motor control. The MSPM0H is a great fit, thanks to its multiple COM ports, reliable analog signal tracking, and fast processing power. Moreover, the MSPM0 family offers a Diagnostic Library that should help reduce the development effort for up to IEC60730 Class-B applications. Finally, the MSPM0H internal ADC and its computational power can be utilized for basic metering functions. (Normally, this is done with a Sigma-Delta ADC. M0H ADC is SAR)

For Motor Drive Control only

In this type of system, the MCU performs an advanced motor control scheme by generating multiple configurable PWMs in the correct sequence based on back electromotive force (BEMF) voltage feedback from the motor. The benefits of a dedicated Motor Drive MCU for these types of applications include offloading processing power from the Main System Control, simplifying communication between the MCU and the motor driver, and enhancing modularity in the system. Some applications may opt to use Discontinuous PWM/2-Phase PWM (utilized to minimize switching losses and enhance efficiency) instead of conventional Continuous PWM. The minimization of switching losses associated with the Discontinuous PWM occurs because, at any given point in time, there are only two phases, rather than the conventional three. This means that only four GaN FETs are switched, rather than six. The MSPM0H can easily handle this because of its advanced timers.

Resources

Order a MSPM0 LaunchPad™ development kit today and a DRV7308EVM today to start evaluating MSPM0 for an Indoor Air Conditioner Unit design. Jump-start a design with MSPM0 code examples and interactive online trainings. The following links show resources that are also available:

- MSPM0-SDK
  - Designs for MSPM0 motor control
- MSPM0 overview page
- MSPM0 LaunchPad development kits
  - LP-MSPM0H3216 LaunchPad development kit
- MSPM0 Academy
- DRV7308EVM
- DRV7308 250W motor inverter reference design
- MSPM0 H-Bridge Control Application Note
- MSPM0 Trapezoidal Control Application Note
- TI Precision Labs - Motor Drivers: Brushless-DC Basics

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